

Driving the Aqueduct Tunnel a Fifth of a Mile Below the Hudson

The recent opening of a seam in the rock and the consequent flooding of the Catskill aqueduct tunnel under the Hudson River at Cornwall was doubtless the first intimation many persons had that actual work on the under river bore had been begun, although official announcement of the starting of the work was made several months ago. From the first reports of the accident people might have been led to believe that the work had received so serious a setback that it might have to be abandoned.

The striking of a vein of water, for it is thought hardly likely that the flooding of the tunnel came from a break reaching up to the river bottom, was not entirely unlooked for, although according to one of the employees it was not expected that water would be encountered so soon and no pumps had been installed, which accounts for the rapid filling of the excavation. The engineers now have the inflow under control and expect before long to resume work.

The work of driving forward this deep channel beneath the river has already reached a stage where the camps of engineers who are pushing out sec-



EAST PORTAL OF BREAKNECK GRADE TUNNEL.

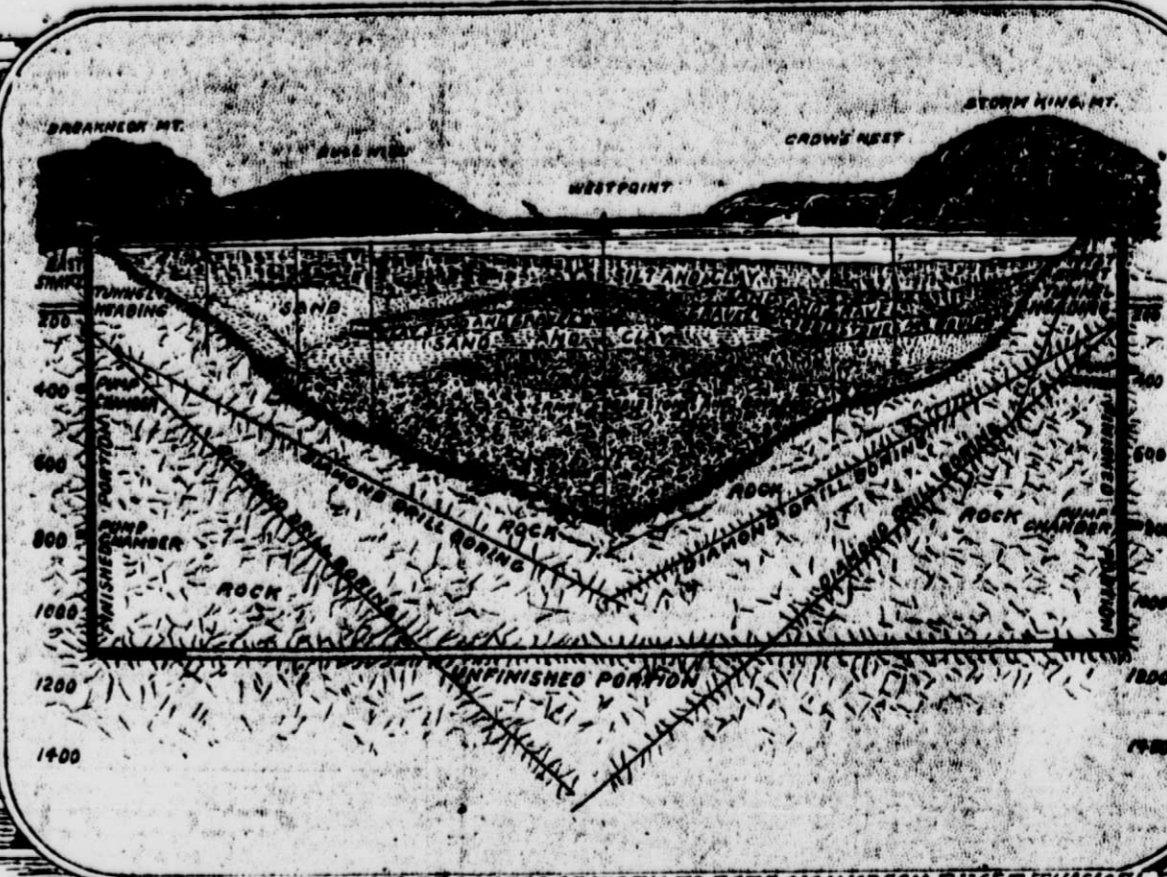


DIAGRAM SHOWING PROGRESS OF WORK TO DATE ON HUDSON RIVER TUNNEL.



BREAKNECK, SHOWING CLIFFS AND POWER HOUSE.



OVER A FIFTH OF A MILE UNDER THE HUDSON, AT EASTERN END OF TUNNEL, STORM KING SECTION.



IN THE HEART OF BREAKNECK MOUNTAIN.

tions of the tunnel from the opposite banks of the river are making friendly wagers as to which party will reach the middle of the Hudson first. One man, speaking for the Breakneck camp, expressed the belief the other day that the Breakneck section would meet the Storm King end of the aqueduct at least 100 feet west of the center line.

"Provided," he added, "we do not strike water."

It was the Breakneck end of the tunnel that was flooded. The point of interest in this remark is in the inference it carried that the striking of water was by no means an unlooked for occurrence or necessarily a serious one.

The discussion as to where the two ends of the tunnel will meet does not by any means carry a prophecy of an early completion of the work. Aside from possible delays due to unusual conditions attendant upon carrying on construction more than a fifth of a mile beneath tide level, the fact that it is necessary to hoist all the excavated material out of only two exits will of itself delay its completion beyond the time when the sections of the aqueduct immediately adjoining it on either side of the river are in finished shape.

No other siphon dips anything like so far down. The top of the tunnel is almost exactly 1,100 feet under the river surface. The bottom of the tunnel is over sixteen feet further down. At the west shaft near the base of Storm King the rock must be hoisted over 1,200 feet, and it must be brought up nearly as far at the east shaft at the foot of Breakneck.

Because of this problem of getting out rock work at the Storm King end has been largely suspended during the last few weeks in order to make changes which will allow excavation to be carried on at a greater speed. These changes include the putting in of a concrete lining in the west shaft.

When that is done the great iron bucket which affords the only method of communication with the surface will be replaced by a large cage into which cars may be run and lifted to the top, thus economizing time and labor in getting out the rock.

From the bottom of the west shaft about thirty feet of tunnel had been excavated eastward toward the center of the river at the time that the general announcement was published, early in the

present year, that the crossing was assured and work begun. Since then this section has been pushed out altogether nearly 200 feet, while the Breakneck tunnel has reached a point 250 feet from the eastern shore.

These are the net results to date, following the long period of experimentation covering a stretch of the Hudson from New Hamburg to Fort Montgomery, when it seemed often that it would be impossible to effect any tunnel crossing at all. Even after the Cornwall location was chosen there were several years of probing in the river's bottom. This part of the work revealed the presence of the astonishing ancient rock gorge of the Hudson whose existence was previously unsuspected. Although the drills which worked from floats anchored in the stream went down over 700 feet they never as a matter of fact reached solid rock except along the sides of the river. The location of the long tunnel for all rock routes was finally found only by probing out with diamond drills pocketed in the rocks 250 feet down the sides of the east and west shafts.

There is no counterpart in connection with the building of the under water tunnels about this city of the driving of the Hudson River siphon of the Catskill aqueduct. As the crossing is through solid rock, the mud shield which played an important part in the building of the North and East River railroad tunnels has no part in the plans. The men do not have to work under compressed air, with its disadvantages. Even at the great depth mentioned the air is pure.

This is noticeable just now in the Storm King end of the bore, where blasting has been suspended for the time being. During the period of active work the depth of the workings and especially the absence of draught—the tunnels being as yet open at one point only—serve to prevent rapid dissipation of the powder smoke, which really never entirely disappears from within the diggings. It is extremely irritating to the lungs and throats of the men, but accepted as a necessary evil, and certainly preferable to the effects of the heads and other disagreeable attendants of mud shield work.

In some respects conditions do not differ greatly from those connected with the straight ahead rock excavation of an ordinary railroad tunnel, but of course it

was hardly to be expected that in so deep a tunnel special problems would not arise for solution. One of the first dangers considered when this work was projected was the possibility of striking a heavy inflow of water at some point from internal reservoirs or through fissures leading up into the river bed, but the geologists, who have very carefully examined the banks of the river, have given pretty definite assurances, so far as they can tell from surface indications, that no important fault exists anywhere along the line of the aqueduct under the ancient Hudson gorge. It is interesting to note that so far as they have been excavated the under river sections of the aqueduct have, up to the time of the Breakneck incident, been almost as dry as a bone.

One very unusual condition has been discovered, unusual enough not only to be of practical interest to the engineers but also to attract the attention of the geologists who have frequently been called into consultation. Far down beneath the river the rock is seen to be under an enormous stress, the effect of which at all times is evidenced by the chipping off of flakes of rock from the roof and side walls of the tunnel, and the occasional dislodging of larger pieces of rock, sometimes with considerable force. A semi-circular steel roof pushed forward as the tunnel advances protects the men from any debris from this source, and it is expected that the solid wall structure which will probably line the cavity upon its completion will, by reason both of its shape and the character of material, protect the work in future years from any strain imposed by the surrounding rock mass.

As to the larger causes which have brought about this rock strain the experts are not entirely agreed. According to one of the geologists the stress is due in part at least to the weight of the mountain masses on either side of the Hudson pressing downward toward each other over lubricated surfaces. At the level where the aqueduct runs beneath the V shaped gorge of the ancient Hudson Valley there is pressing downward toward a common point or line the weight of solid masses of Highland rock rising about 2,500 feet above that level, these masses being represented, above and below the river's surface, by Storm King and Breakneck and other mountain masses supporting them.

It is the belief of another scientist that the condition of stress is not necessarily due to purely local causes, but may have a more general application, with some connection, perhaps, with the shrinkage of the earth's crust. He cites the case of deep rock excavations in Germany and elsewhere where somewhat similar conditions have been encountered.

Although this is one of the most interesting things connected with the progress of the undertaking, it is probable that the average visitor will find his attention held by the more practical evidences of the work about him. Before descending into the west shaft he will have to slip on long rubber boots, oil-skin coat and tarpaulin, for he will find plenty of spray during a part of his journey downward, as he stands on the rim of the big bucket and holds onto the chain for support.

His first sensation will be one of being dropped rather more rapidly than any skyscraper elevator ever carried him down to street level. As a matter of fact he reaches the bottom of the twelve hundred and odd feet shaft in a little over two minutes.

His ascent of the shaft seems to be even a little more swiftly accomplished than the descent. He wonders what would happen if the bucket began to swing toward the sides of the rock. Somebody tells him it wouldn't have time to do that. Then he notices that as the bucket rushes upward, apparently straight at a projecting beam, where a side excavation holds the pump, the speed slackens until the obstacle is safely passed, then resumes its former rate. He learns that the man at the top who operates the hoisting apparatus has before him a guide which, like an elevator indicator, tells just where the bucket may be at any particular time, and he regulates its speed accordingly.

The work on and around Breakneck has picturesque features which make it somewhat notable. In fact, the topographic conditions at this Hudson River crossing, in connection with the engineering and geological features of interest, make a distinct appeal to the imagination. There is the incline railway. This is an institution of the aqueduct work, and he

who is invited to take a trip up its length may count himself fortunate. Its long line of lights at night, leading from the shore nearly five hundred feet up the mountain side, makes Breakneck a conspicuous object.

Up this incline were brought nearly all the machinery and other material gathered at the works built at the mouth of the shaft on a shelf dug in the mountain side. It may surprise some persons to learn that digging is going on so far up the side of a mountain. It should be borne in mind that the standard grade or level at this point is about four hundred feet above the river level. The aqueduct happens to reach the river on the west shore about six hundred feet below grade, or 200 feet below the surface of the river, but on the east side it comes back to grade, or nearly so. This means that when the aqueduct is in operation a column of water 14 feet 8 inches in diameter will rise perpendicularly from the river tunnel to a height of 1500 feet, into the very center of Breakneck, where it will turn at right angles, pass completely through the mountain, and coming out of the southern side flow across Breakneck Valley within a cut and cover digging, and pass through Mount Taurus, or Bull Hill, in a tunnel a mile long from end to end and with a thousand feet of rock piled above it.

It might seem as though the uprising of this immense core of water for so great a height, nearly three-tenths of a mile, was a defiance of the laws of nature. It will be remembered, however, that here is an inverted siphon, and that the section of the aqueduct which passes through the center of Breakneck so far above the river is actually at a lower grade than the section a few miles west of the river. The water will be merely seeking its level.

Strictly speaking, the ascent of the water into Breakneck will be made in two steps. The shaft being sunk from near the top of the incline railway will go down to a point about 200 feet below river level and then connect by a horizontal tunnel about 900 feet long with the east shaft.

Some measure of fame in the engineering world has lately come to this upper Breakneck shaft and to the superintendent who has it in charge. On April 8 last the American record for sinking a shaft through rock was broken, the excavation being deepened 182 feet in 27 days, the

record standing as covering 31 days, that is, from March 8, with four Sundays taken out. The world's record of something over 200 feet was made with Kaffir labor in South Africa. The best previous work, also an American record, was 177 feet, by the same superintendent, Walter Steenburgh, at shaft 1 on the Moodna siphon.

The kind of rock, the size of the shaft, and the number of men working are not considered in connection with the breaking of records of this nature, it being considered that when conditions differ one factor balances against another so as to bring about a general average of result. Thus too many men at work would get in one another's way and too small a shaft would increase the difficulties of excavation and removal. The work in this case from high up on the side of Breakneck was carried on in three eight hour shifts and the rock penetrated was a hard granite gneiss.

For half its distance downward this shaft represents a section of completely finished aqueduct, and as one swings far down into its depths on the edge of the slowly revolving bucket and looks upward toward the rapidly decreasing hole which marks the mouth of the excavation he gets an interesting and unusual view of the smooth, shining concrete lining which marks the completed work. The perspective in this upward view from the mountain's centre is such that the circular wall seems to bend around to meet the tiny patch of light at the top, giving the illusion of a strange and wonderful dome.

The descent into this shaft is very different from that into the west shaft near the river shore at Storm King. The upward which rises from its depth is such that it is impossible for the men in the bucket to converse. The bucket stops a dozen feet above the bottom. Looking over the edge one sees a weird sight. Incandescent lamps illuminate the floor, ranged about the pool and radiating from the centre where the bucket swings in the air drills are pounding vigorously into the rock. Attending there are twelve men and a boss. They are clad not in the yellow oilskins such as the visitors wore in the west shaft, but in black rubber coats and hats, which look intensely black and shine as though

polished under the film of water which covers them.

It is hard to realize that the journey down this shaft from the point far up Breakneck's side has brought one to a spot well below sea level, but such is the fact. In a period of seconds rather than minutes one is back in the sunlight once more looking off on the panorama spread before the eyes at the top of the incline and preparing to enter on still another journey into the mass of the mountain.

This time it is through the tunnel which shoots out in a horizontal direction from the shaft into the middle of the mountain and through to the southern side. This tunnel has already been driven entirely through the mountain, although much of it is yet in rough shape.

There are several interesting things about this tunnel. It is not driven through the hill in a straight line, but describes an arc. The reason for this is the presence of the southern precipices of the mountain. It was not proposed to give nature a chance to spill this river which is to flow through the mountain by any tricks which it might play with the big cliffs near by and so the aqueduct was made to bend away from them. As it is, the tunnel is only 300 feet back of their face at one point.

Also in order to safeguard the work the city took over the ownership of the cliffs and in fact of a large part of the mountain, thus preventing any further quarrying in the vicinity.

At the top of the upper Breakneck shaft will be a gate house and near the foot of Storm King will be another. These permanent structures are designed to control the flow of water in the Hudson River siphon. At the foot of Breakneck will be another permanent building—a pumping station. It will probably stand there unused for years, the longer unused the better, but it must always be kept in shape for service at any moment. It is designed for emergency, to drain the great siphon if necessary, in order to enter beneath the river for repairs or other purposes.

In several ways the Catskill aqueduct work has been compared with the construction of the Panama Canal. It is safe to say that not a few persons who have journeyed from New York to the isthmus to inspect the progress of the canal project have quite overlooked the highly interesting and instructive work which is being carried on almost at the city's doors.

PERFIDY OF PUNCH BASCOMB

Clouds Over Montela as a Result of a Match Game of Dominoes.

"I had always found Montela, up among the Ulster county hills, such a cheerful and buoyant community," said John Gilbert, the traveling grocerman, "that I was not only puzzled but amazed on my last trip up there, not long ago, to find it in a morbid and traitorous mood, its old spirit lacking and with an apparent disposition of one portion of its folk to look with resentment not unmixed with suspicion on another portion of it. I appealed to my old friend Sykes, who is a considerable part and parcel of that community."

"What in the world ails Montela?" said I.

"Sykes knew a world and said: 'Dominoes!'"

"I suppose you have guessed it Sykes, that his report of the domino match for me a month back, and with another deep sigh he made things plainer."

"As I guess you know, John," said he, "Montela has always been as

quiet as mill ponds, peaceful as lambs and cheerful as crickets. She never showed any sporting blood to speak of, a game of pinocle now and then or a venture at hearts or a joist with old maid or single being the height, depth and breadth of her social disposition."

"That was up to the time that Ike McCorkle came back home from some-where last winter bringing with him warm recommendation of the game of dominoes, with which he had come in contact while away. Soon dominoes took possession of Montela and peace and quiet and cheerfulness got up and left."

"Even quelling bees were turned into domino players. The weekly sessions of the Montela Debating Society became parties of progressive dominoes. Where ever men gathered they discussed dominoes instead of the weather, fish, birds, city borders and the price of eggs. It wasn't long before rivaling players of the game new to Montela became warm."

"Two notable groups of experts came out of the general mass of domino devotees. One became known as the store outfit and the other as the hotel bunch, according to where they played, at Richman's store over yonder or down to Parker's hotel."

"Of course the store outfit predominated and outnumbered at the clubs of the hotel bunch as players of the game as it should be played, and the hotel bunch as a very

presuming to know what dominoes was. So it was a matter of course that by and by talk on both sides became loud and persistent for a championship test between them, and one was at last provided for."

"Pete Casawise and Dug Passmore were chosen to uphold the banner of the store outfit and carry it to victory. Sam Plotz and Ike McCorkle were selected as the invincible two to see that the hotel bunch trailed that banner in the dust. As neutral ground on which the battle was to be fought Herman's store was selected."

"From the time this game was arranged for, until last night, when it was played, nothing else was thought, talked or discussed of in all Montela and no one could adjourn but remove. Paper and excited delegations from Eurka, Lakka, wack, Sindown, Pokenessie, Kyssacke, Poutabunk and other points poured into Montela on foot and a-horseback. And the Souze Club was never so busy on the job."

"The teams were settling down at Herman's to begin the tournament, best three in five, when Punch Bascomb of Eurka spoke up and said:

"Seems to me there ought to be a little something up on this game to make it a little more birdin'. 'Spoon we bet a game," says Punch."

"Then the matter of the legal status of betting caused a halt and it was de-

cided that each side should take up a collection and the sum total be held as a bonus to go to the winning team. The hat was passed for the hotel bunch by Will Horton. Hank Byford looked after the contributions for the store outfit. When the collection was counted it was found that the hotel bunch's backers had come across with \$3.19, while the rooters for the store outfit had confidence in it to the extent of \$2.40. The total of this sum was confided to the custody of Will Horton and Hank Byford to await its distribution among the triumphant players."

"Then the word was given and the first game was begun amid an awful clacking, which was broken only by words of advice, admonition, disapproval, protest and the like from vociferous on-lookers, according as this, or the other player's play struck them as different from the way they'd have played it themselves. Casawise and Passmore won the first game by a close shave and the second only by a nose, but the enthusiasm of the store outfit almost lifted the roof of Herman's store."

"But say, maybe the hotel bunch and its adherents didn't yell when McCorkle and Plotz swiped the two succeeding games, easy. Before starting the fifth and deciding game, though, it was moved by Punch Bascomb of Eurka that as the tension on the nerves of everybody was at a point that endangered its snapping in two, the two teams, and such friends

as they might invite to go along, adjourn to Parker's Hotel and take a rest. The eyes had it, and the four players called an armistice and went down to Parker's. And almost everybody else went too."

"A half hour at Parker's served for them to get all the rest any one seemed willing to buy, and they returned to the store to tackle the fifth, last and deciding game. The score was even at the beginning of the tenth hand. Then Ike McCorkle blocked the game."

"The silence was so thick as the count was taken on which side had the smaller number of pips and thus win that you could have chipped chunks out of it with a knife. McCorkle and Plotz had a total of 68 pips on their unplayed pieces. With a voice that wavered with suppressed emotion and quivered with chagrin Dug Passmore announced his and Pete Casawise's count."

"Seventy-three!" said he, and heaved a sigh.

"While the exultation of the hotel bunch might not have been unbecomingly profuse, but in the midst of it Dug Passmore, who had been silently looking over things, rose and shouted:

"Hold on! I protest this game! There's 240 counts on this set of dominoes and there ought to be only 108. More than that, there's thirty-six pieces and there oughtn't to be but twenty-eight."

"Where's Punch Bascomb of Eurka?" said he, "Bascomb wasn't there. Some one said he seen him hitch away a while ago in his buckboard. Then amid much postulation and loud indignation from the unembodied players and their friends the contributors to the bonus fund for distribution among the victors in the tournament said they guessed they'd see Will Horton and Hank Byford and kind of collect their money back. They saw Will and Hank, and Hank said:

"The fact of the matter is, boys, there hasn't no money to collect back. Punch Bascomb of Eurka kind of thought a little game of seven up'd be sort of revivin' while you fellers was over to Parker's takin' your rest and me and Will Horton and Hank Byford and kind of collect their money back. They saw Will and Hank, and Hank said:

"For a time last evening, John," said my friend Sykes, shaking his head mournfully, "I looked as if there would be a social upheaval at Herman's store that would call for surgical aid but it was permitted to pass with nothing fiercer than the hotel bunch' monition that the store outfit was a cowardly coniver, and the store outfit giving its opinion that the hotel bunch was a crawfish in count."

"And the trail of the serpent is over all Montela like angworm tracks in the mud, and we are in the dumps clear to the top of the mountain. John, it may not be wise for you just now to suggest a tourney at dominoes, best three in five, to either the hotel bunch or the store outfit. Not just now."

"I said I would bear the hint in mind, and when I came away there was no rift yet in the cloud that hovered over Montela."

ANCIENT INDIAN MINERS.

Their Method of Working Copper Deposits of Lake Superior Region.

From the Southern Workman. The copper mines in the Lake Superior region were most important to the Indians. When we remember that they did not understand the smelting of ores we can appreciate the value of these mines. In them the native metal occurs both in small pieces and great masses. The Indians had only to dig away the earth and smash the rocks with stones, some of which they provided with grooves and attached to a handle by means of a wire around the groove.

Archaeologists have found that they also built fires upon the rocks and thus cracked them so that they might more easily be smashed with hammers. One piece of copper propped upon poles over fifteen feet below the surface of the ground was found by explorers where it had been abandoned by the Indian quarrymen. Weighing almost three tons, it was a monument to the industry of the North American Indians, who have too often been considered idle, and who, we must remember, had only the simplest tools with which to raise this heavy mass.

These were exceptionally deep shafts, many others being smaller. In one place an area of about six acres had been so excavated, judging from the number of hammers or mauls found in a given bank of the debris excavated from these ancient diggings, thousands and thousands of the hammers must have been used and may be found by clearing out the old workings.